



# Aviation Safety Program

John White

Director (Acting), Aviation Safety  
Aeronautics Research Mission Directorate



# Aviation Safety Program

## *Research Thrusts*

**Integrated Vehicle  
Health  
Management**

**Integrated  
Intelligent Flight  
Deck**

**Integrated  
Resilient Aircraft  
Control**

**Aircraft Aging &  
Durability**

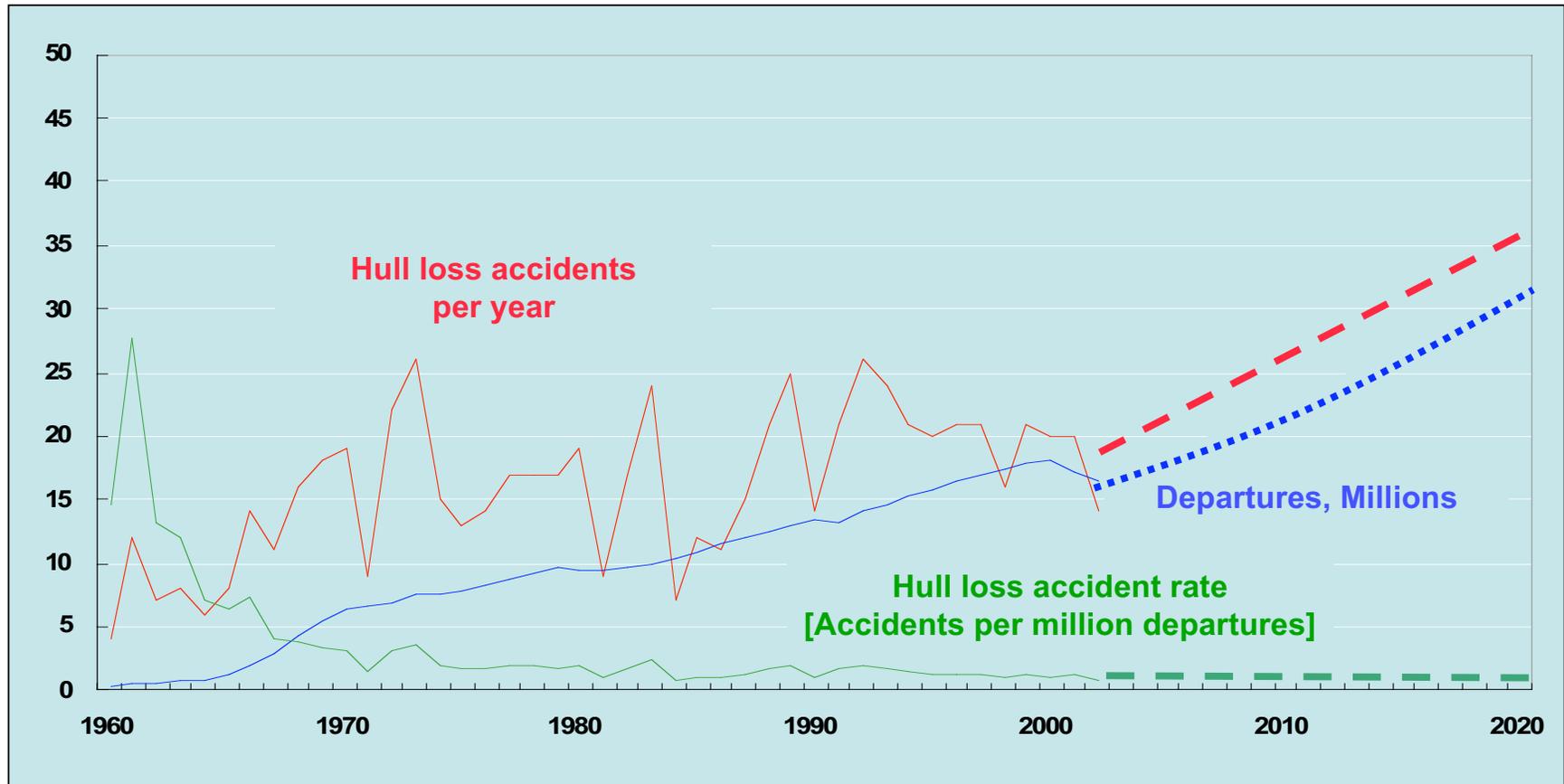
Develop technologies, tools, and methods to:

- Improve inherent safety attributes of new and legacy vehicles
- Overcome safety technology barriers that would otherwise constrain full realization of the Next Generation Air Transportation System



# Safety Challenges

## Expanding Capacity





# Safety Challenges

## Expanding Capabilities



### Next Generation Air Transportation System

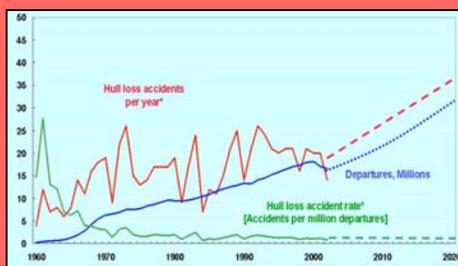
- Equivalent Visual Operations
- Super Density Operations
- 4D Trajectory Management
- Weather Assimilated into Decisions



# Safety Projects

## Project Areas

### Challenges



Data Driven Requirements

#### Integrated Intelligent Flight Deck

- Optimum Workload Allocation
- External/Internal Situation Awareness
- Off Nominal Behavior Detection
- ...

#### Integrated Resilient Aircraft Control

- Prevent Loss-of-Control Accidents
- Autonomous Vehicle Mission Management
- V&V of Complex Flight Critical Systems
- ...

#### Integrated Vehicle Health Management

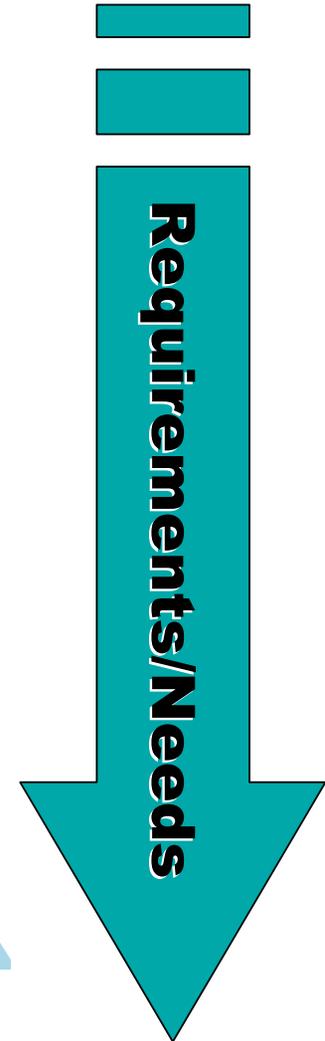
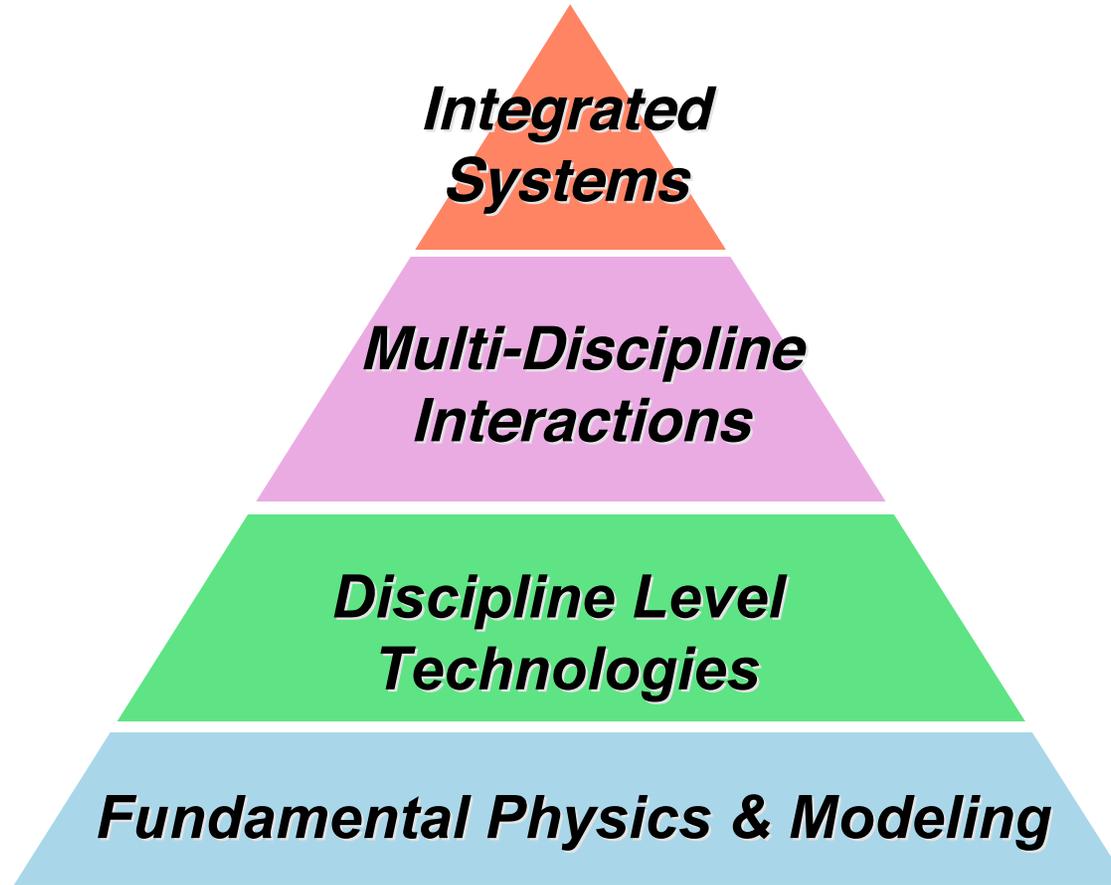
- Prevent System and Component Failures
- Self Recovery from Malfunctions
- Improve Maintenance
- ...

#### Aircraft Aging & Durability

- Damage Science for Materials & Structures
- Detection and Integrity Assessment
- Design for Reliability and Durability
- ...



# Research Hierarchy





# Approach

---

*Space Act Agreements to collaborate with industry; Establish partnerships with other Government Agencies (FAA, DOD, etc..)*

*NASA development of multidisciplinary technology solutions and validation methods*

*NASA development of discipline-related solutions and validation tools*

*In-house research, supplemented with Universities and companies performing foundational research to address technology gaps*

Solve aeronautics safety challenges for a broad range of vehicles with system-level optimization, assessment, and technology integration

Level 4

Integrate methods and technologies to develop multi-disciplinary solutions

Level 3

Leverage the foundational research to develop technologies and analytical tools focused on discipline-based solutions and efficient validation processes

Level 2

Conduct foundational research to further our fundamental understanding of complex safety-related problems facing aeronautics community

Level 1



# Four-Step Planning Process

---

Step 1: Assess the long-term research needs and goals in the Aviation Safety program and establish technical roadmaps to accomplish those goals.

Step 2: Solicit information on key areas of interest from the external community and determine opportunities for collaboration through an RFI

Step 3: Develop research proposals at the field centers

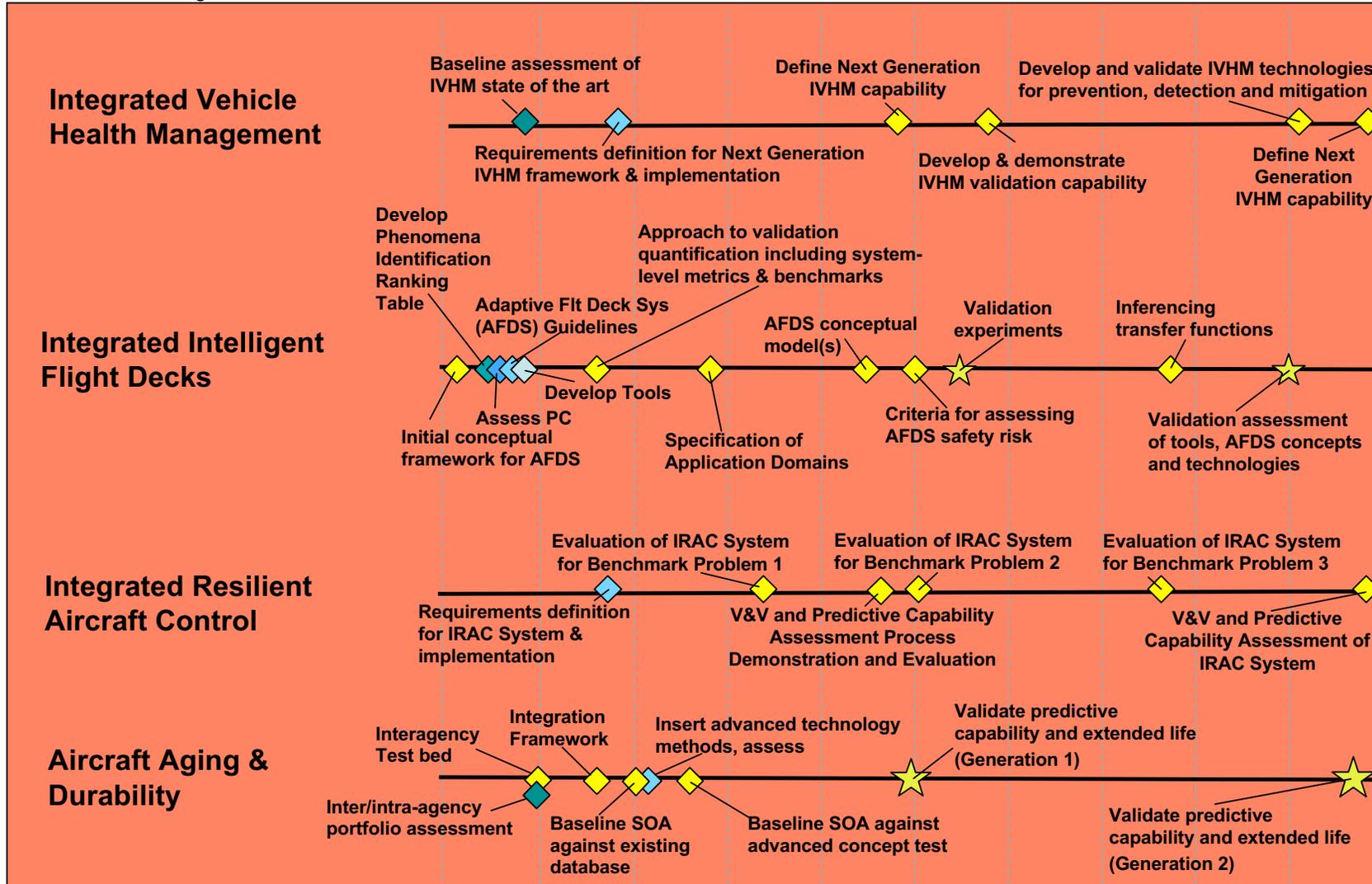
Step 4: Issue a NASA Research Announcement to solicit proposals for foundational research in safety related problems



# Aviation Safety Top Level Roadmap

◆◆◆ Re-curring milestones

FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16





# Integrated Vehicle Health Management

LEVEL 4

**Multidisciplinary Vehicle-Wide Health Management System, Tools, and Technologies for:**

- Graceful Recovery from In-Flight Failures (SAFETY)
- Preventive and Adaptive Systems for In-Flight Operability (SAFETY, PERFORMANCE)
- Informed Logistics & Maintenance (COST, PERFORMANCE)

LEVEL 3

Integration & Assessment of Adaptive IVHM Systems into Vehicles

Airframe

Propulsion

Aircraft Systems

Environmental

System Architectural Framework

Validation & Predictive Capability Assessment

LEVEL 2

Integration, Understanding, & Assessment of Self Aware and Adaptive Subsystems

Intelligent Sensing, Monitoring, & Diagnosis

Prognosis

Failure & Hazard Mitigation

Architecture & Information Management

Characterization, Validation & Predictive Capability

LEVEL 1

Integration & Assessment of Models, Materials, and Smart Subsystems/Components

Physics Based and Data Driven Modeling

Sensor and Actuator Technology

State Awareness

Advanced Materials for IVHM

IVHM Architectures

Analytical, Simulation, and Experimental Methods and Techniques

Advanced Data Analysis & Data Mining

Detection Theory & Reasoning Methods

Design Methods



# Integrated Vehicle Health Management: Research Topics

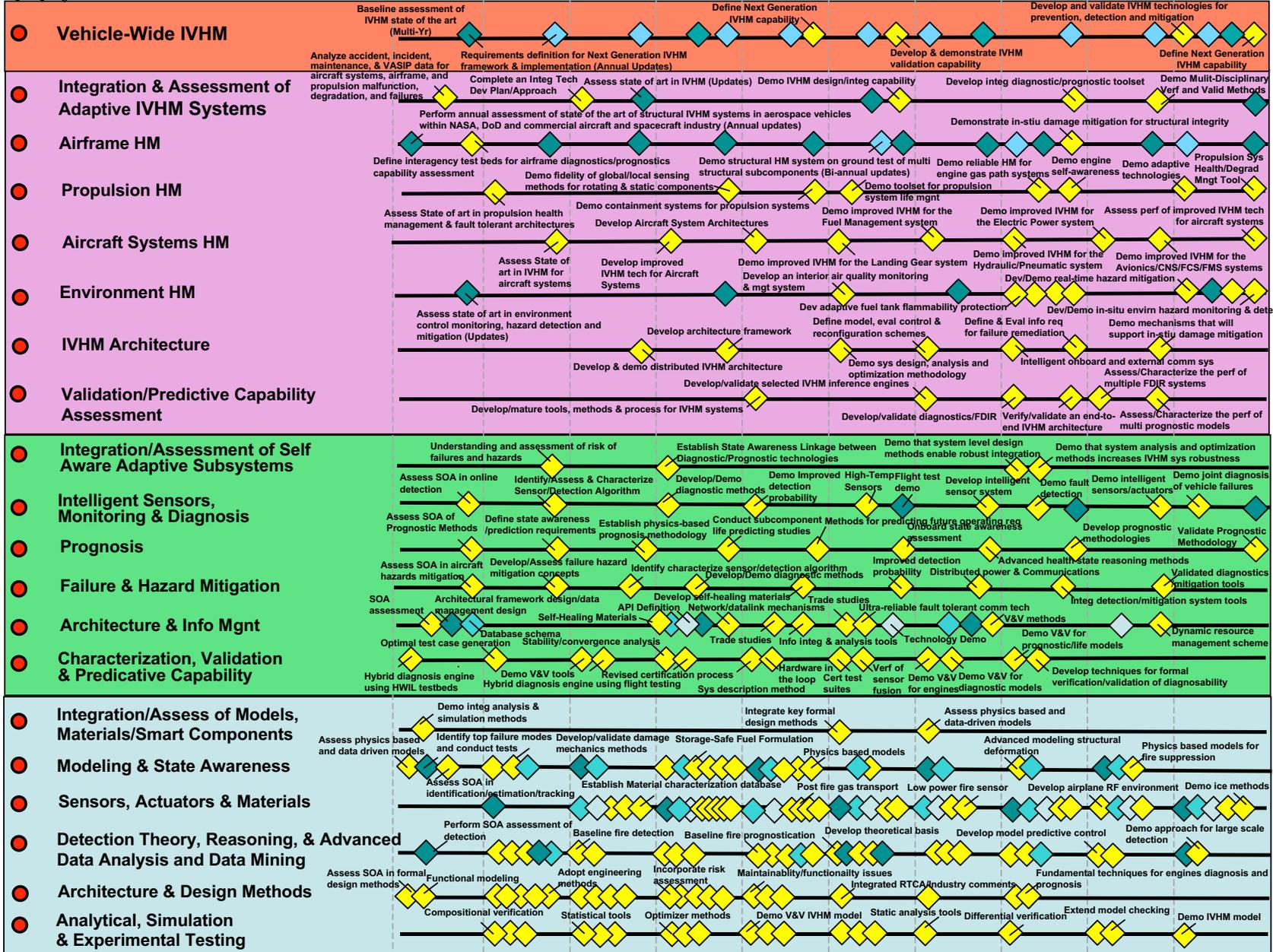
---

Airframe Health Management	Self-awareness and prognosis; anomaly detection and identification; in-flight damage, degradation and failure mitigation.
Propulsion Health Management	Self-awareness and prognosis of gas path, combustion, and overall engine state; fault-tolerant system architecture.
Aircraft Systems Health Management	State-awareness and prognosis of landing gear, hydraulic and pneumatic systems, electrical and power systems, fuel and lubrication systems, and avionics/communication-navigation-surveillance/flight critical/flight management systems; robust distributed fault-tolerant self-recoverable architectures.
Environment Health Management	Prevent, detect, and mitigate the effects of hazards such as onboard fire and fuel detonation; interior air quality degradation; ice; lightning strikes; EMI/EMC; and ionizing radiation.
System Architectural Framework	System design, analysis and optimization; information management, data flow and communication; control and reconfiguration; architecture development and validation.
Validation and Predictive Capability Assessment	Analysis, simulation, ground-testing, flight testing, environmental testing, and software assurance.



Re-curring milestones (yearly, every 2 yrs, etc)

FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16



Level 4

Level 3

Level 2

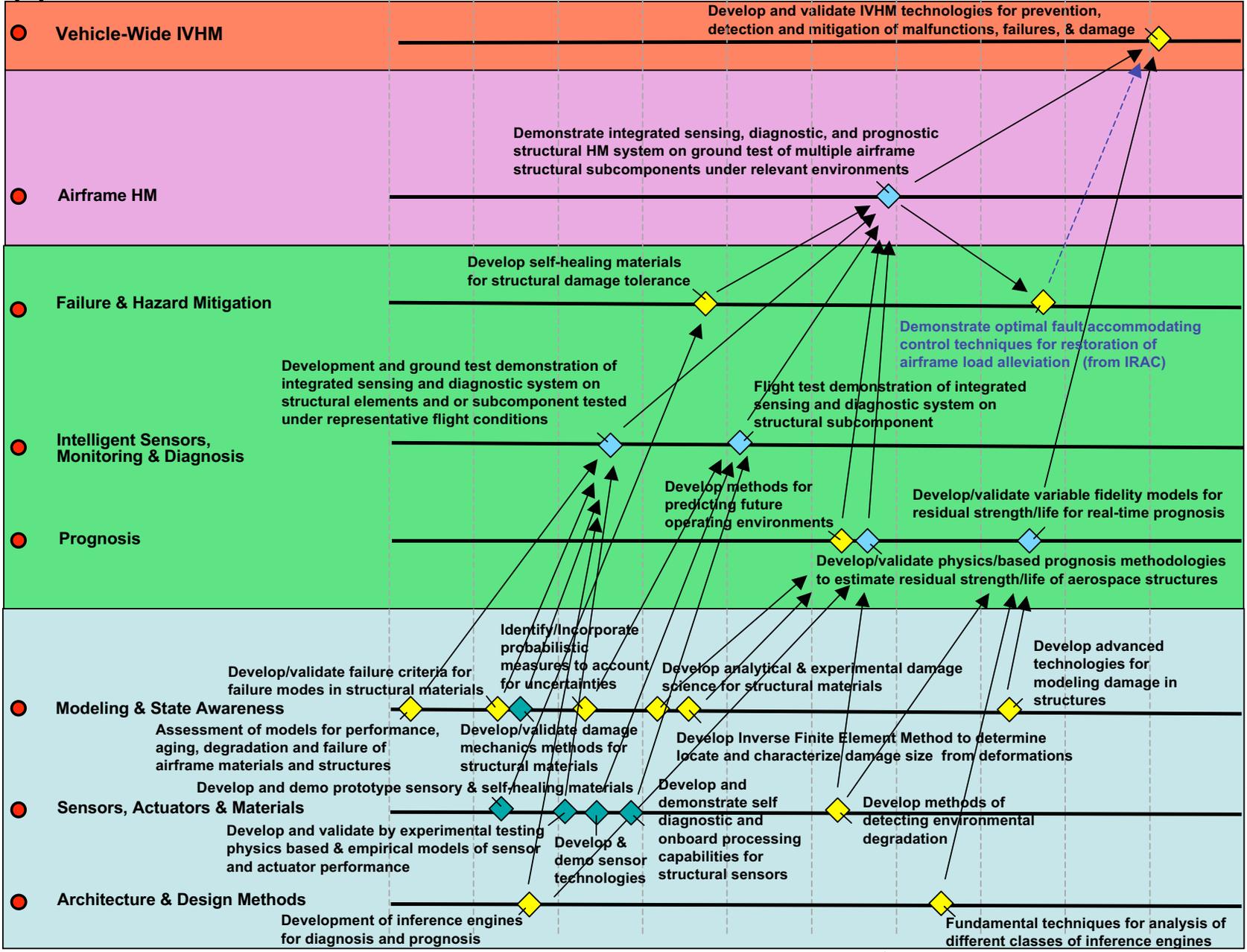
Level 1



Technology Flow / Requirements Flow

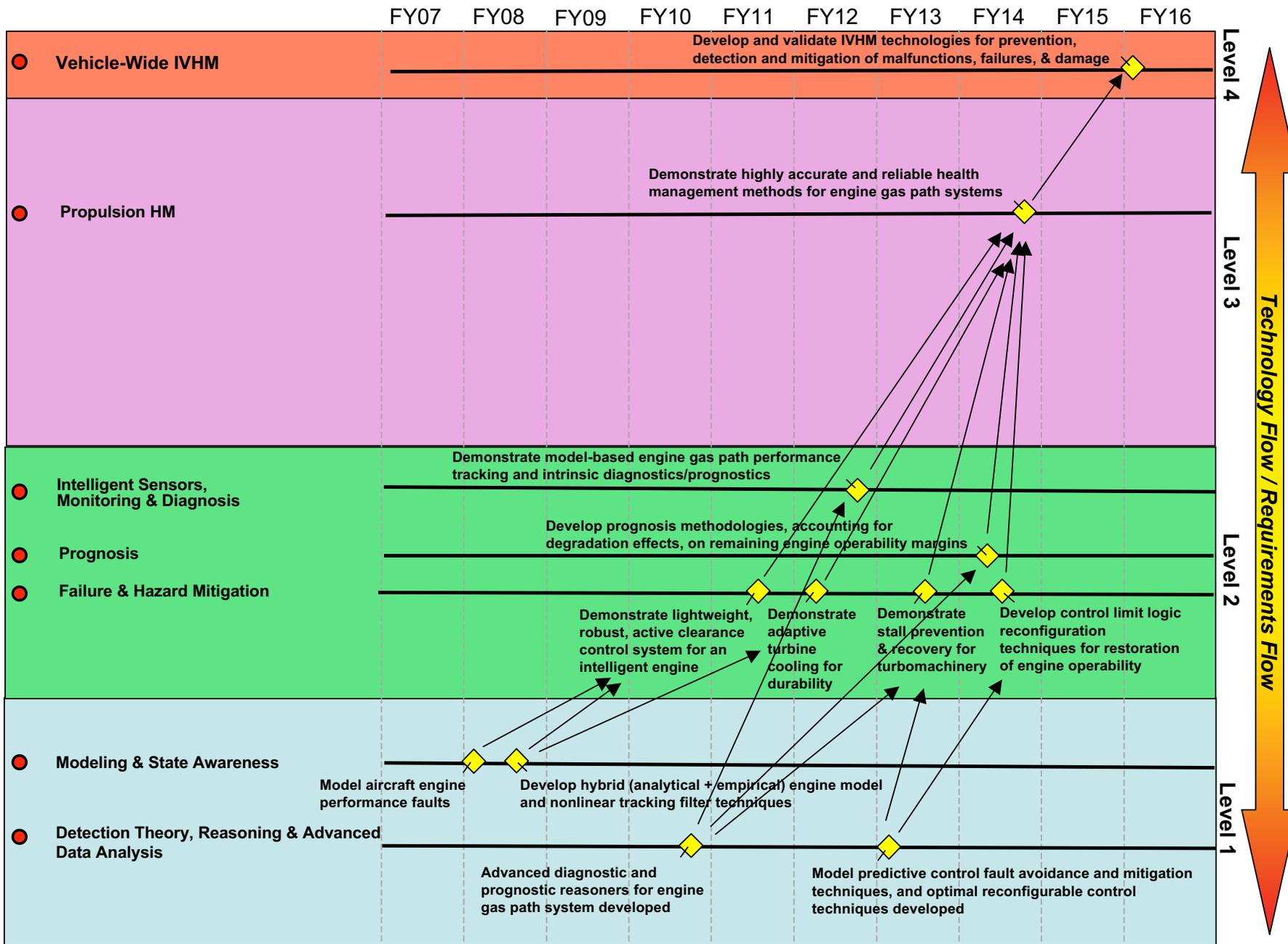
◆ Re-curring milestones

FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16



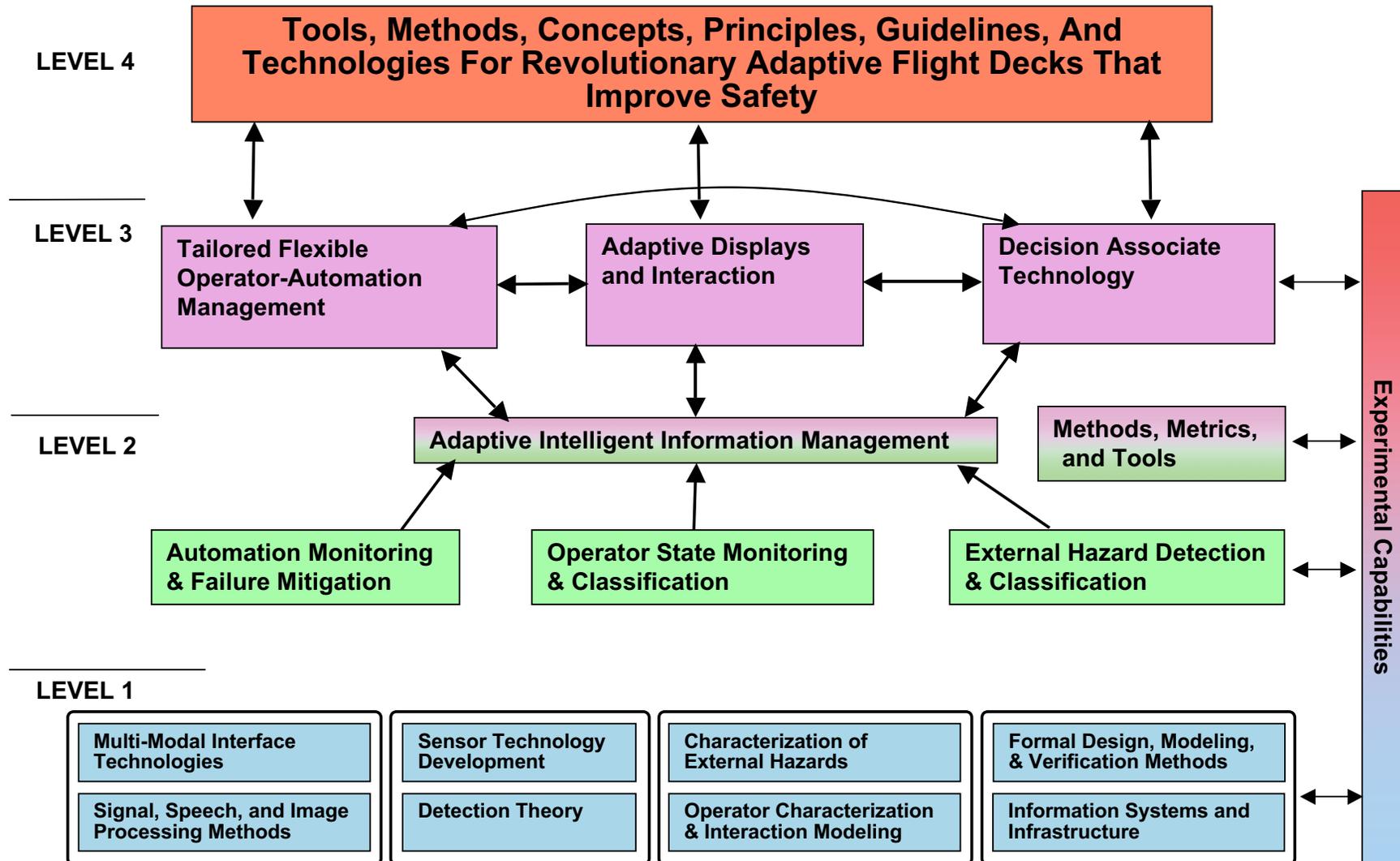
Level 4  
 Level 3  
 Level 2  
 Level 1  
 Technology Flow / Requirements Flow

▲ Annual portfolio assessment reviews at Level 4 not shown





# INTEGRATED INTELLIGENT FLIGHT DECK

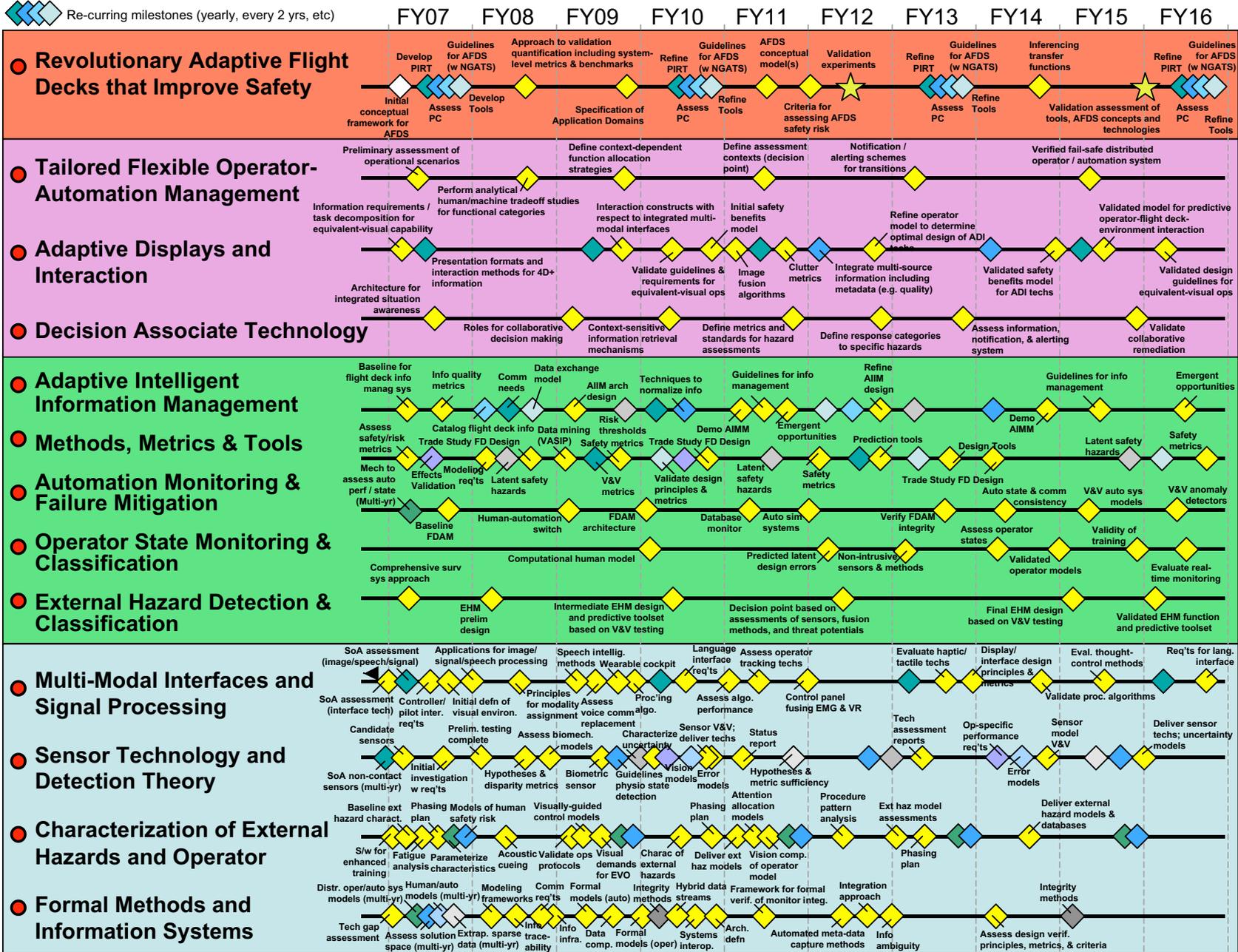




# Integrated Intelligent Flight Deck: Research Topics

Tailored Flexible Operator-Automation Management	Dynamic operator/automation function allocation strategies with formally verified fail-safe reversionary modes for automation assigned functions
Adaptive Displays and Interaction	Equivalent visual environments; spatially-integrated displays that enable optimal presentation and management of flight deck information; optimized controls and displays that support extra- and intra-flight deck information coordination
Decision Associate Technology	Tools and functional capabilities that support hazard remediation; situational awareness and analysis; integrated crew advisory and warnings; collaborative decision making; and tactical guidance and re-planning
Intelligent Information Management	Information systems that support the needs of technologies above while enabling integrated flight deck and external environment state assessment and safety analysis, tracking of real-time navigation, communication and surveillance performance, supporting collaborative information management (with ATC/AOC), and providing predictive information.

Re-curring milestones (yearly, every 2 yrs, etc)



Technology Flow / Requirements Flow

Level 4

Level 3

Level 2

Level 1

▲ Annual portfolio assessment reviews at Level 4 not shown



# Integrated Resilient Aircraft Control

LEVEL 4

## Integrated Modeling, Control, and V&V Technologies for Hazard-Resilient Aircraft Control & Flight Management:

- Graceful Recovery from In-Flight Failures/Damage, External Disturbances, Upsets, & System / Control Input Errors (SAFETY)
- Effective Mission Management under Adverse/Upset/Hazard Conditions (SAFETY, PERFORMANCE, COST)

LEVEL 3

## Integrated Design, Implementation, and V&V of IRAC Subsystems

Resilient Flight Control

Resilient Propulsion Control

Resilient Airframe Control

Resilient Vehicle Mission Management

Safety-Critical System V&V

LEVEL 2

## Integration & Assessment of Flight Safety Prediction and Control Remediation Subsystem Components

Intelligent Sensing, Monitoring, & Diagnostics for Vehicle Control

Flight Safety Prognostics

Coupled Hazard Effects & Vehicle Response Characterization

Control Mitigation & Recovery

Control Autonomy

V&V of Complex Systems

LEVEL 1

## Characterization and Assessment of Safety-Critical Adverse / Upset / Hazard Conditions and their Effects on Vehicle System Safety and Control

Advanced Control Structures

Resilient Materials

Robust Design and Risk Analysis / Mitigation

Instrumentation for Resilience

Vehicle Dynamics & Hazards Effects Modeling

Simulation of Complex Systems

Detection, Identification, & Prediction Methods

Control and Guidance for Hazards Conditions

Validation of Complex Models & Systems

Software Safety Assurance & Formal Verification Methods for IRAC



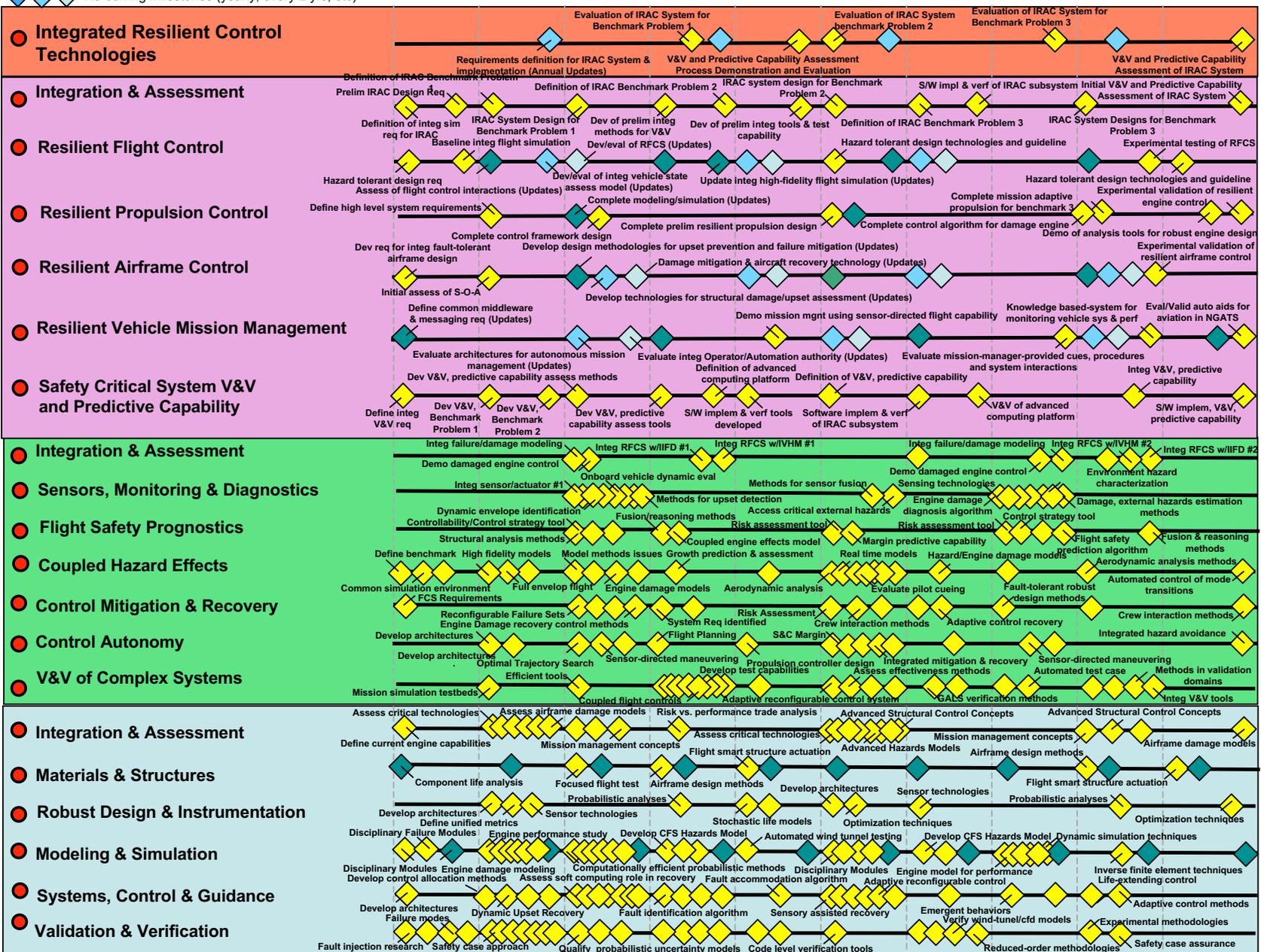
# Integrated Resilient Aircraft Control: Research Topics

---

Resilient Flight Control	Fault tolerance and hazard effects protection; onboard hazard effects assessment, mitigation and recovery
Resilient Propulsion Control	Damage tolerance and design for extended envelope operation; onboard hazard effects assessment, mitigation and recovery
Resilient Airframe Control	Damage tolerance and structural damage avoidance; onboard damage effects assessment, mitigation and recovery
Resilient Vehicle Mission Management	Control and performance management; vehicle-based mission management and autonomous collision avoidance; interface and communication management
Safety-Critical System V&V	Safety assurance methods for complex avionics systems; integrated V&V methods, tools and test techniques for adaptive control systems; predictive capability assessment methods and tools

◆◆◆ Re-curring milestones (yearly, every 2 yrs, etc)

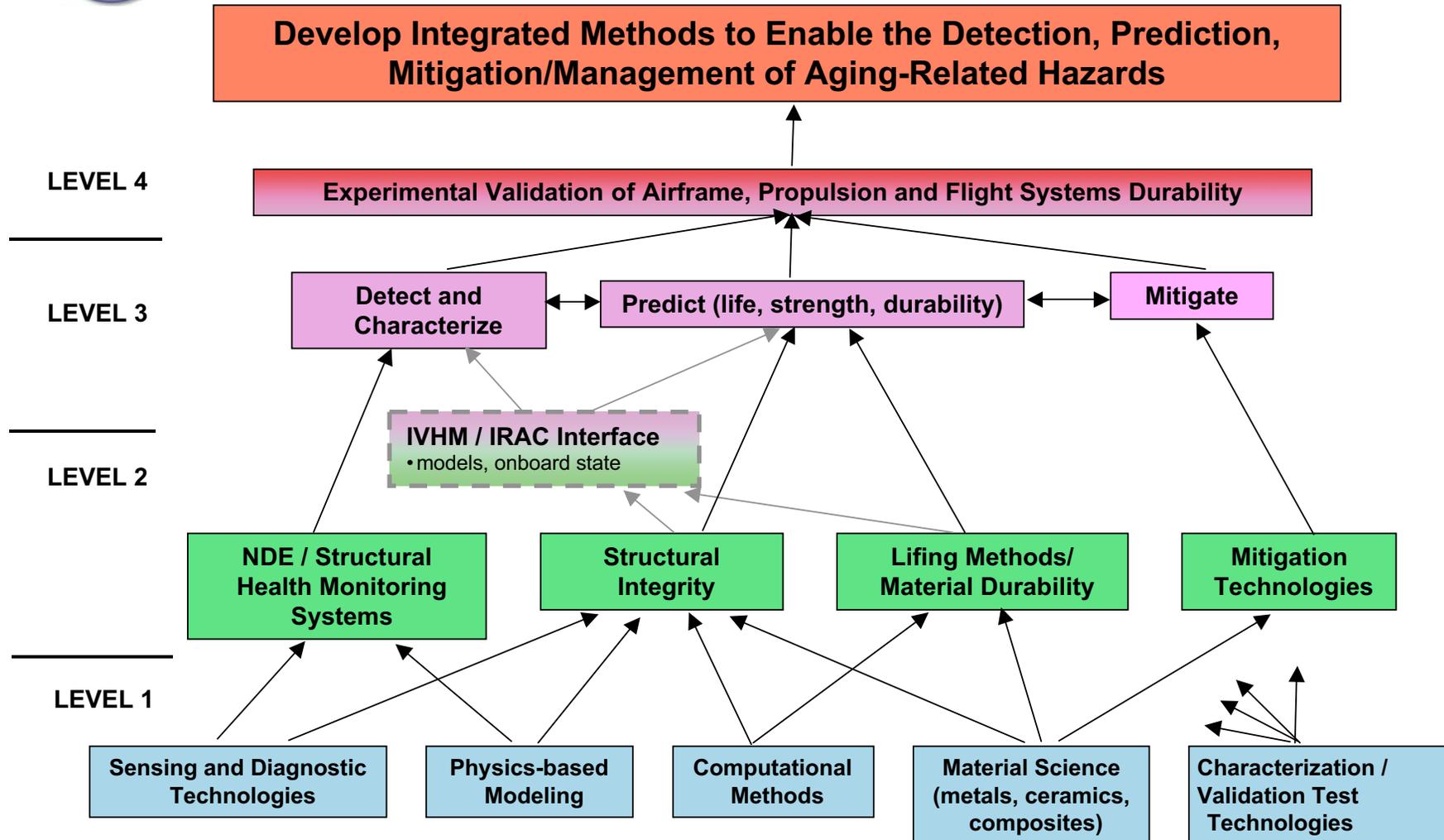
FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16



Level 4  
Level 3  
Level 2  
Level 1  
Technology Flow / Requirements Flow



# Aircraft Aging & Durability

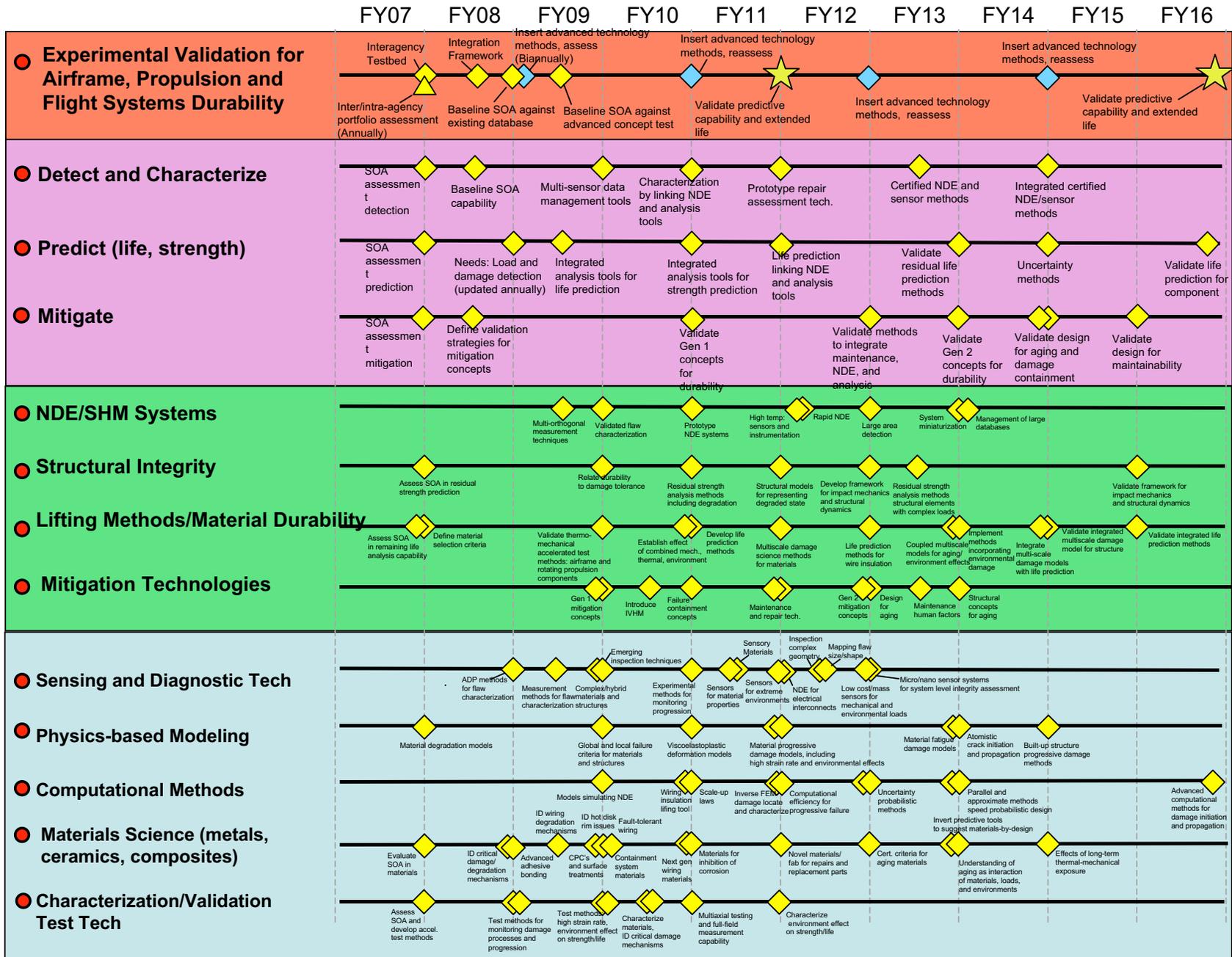




# Aging Aircraft & Durability: Research Topics

---

Detection and Characterization of Aging Related Hazards	Establish linkage between structural analysis and NDE techniques; Damage and environmental state quantification; repair assessment
Prediction of Life, Strength, and Durability of Aircraft Systems with Degradation	Variable fidelity analysis methods and predictive tools; methods incorporating usage and NDE information; reliability/margins of safety with uncertainty
Mitigation of Aging Related Hazards	Advanced material systems (surface treatment/coatings, multifunctional); degradation management; design for aging prevention, maintainability/repair, and damage containment

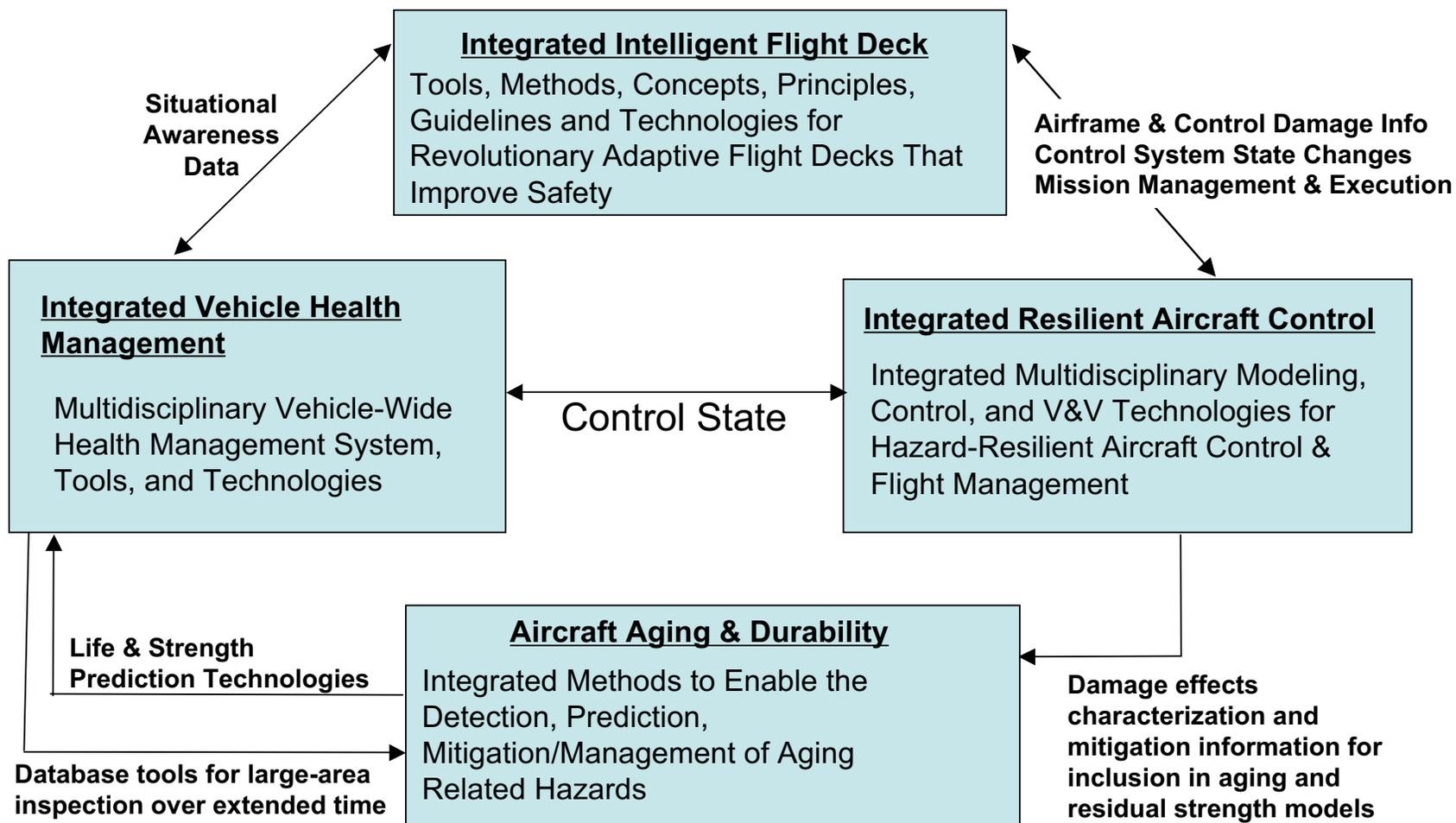


Technology Flow / Requirements Flow



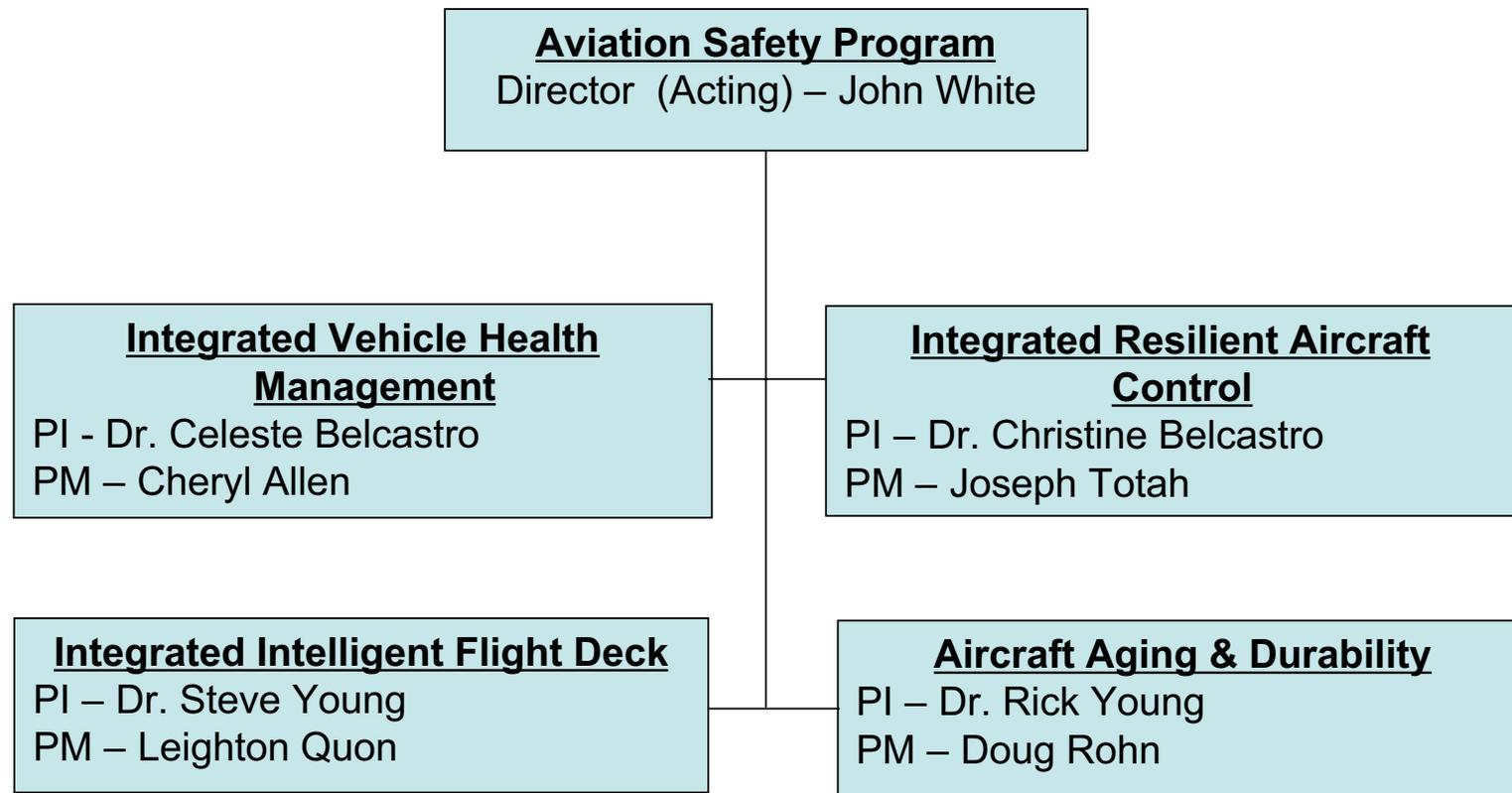
# Aviation Safety Program

## Project Area Interdependencies - Examples





# Safety Program/Project Leads



Principle Investigator (PI)  
Project Manager (PM)